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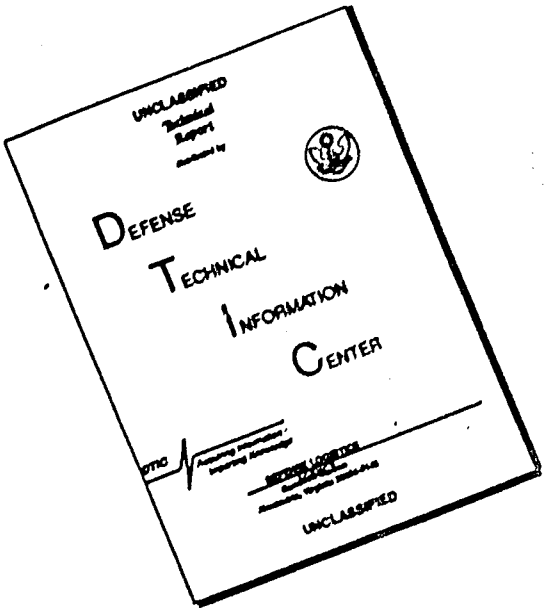

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COATING and CHEMICAL LABORATORY

ENGINEERING STUDIES ON SOLUBILIZATION ADDITIVES

FOR WATER IN MINERAL OIL

Report No. CCL # 118

OMS Code No. 5010.11.8020.0

D. A. Project No 8R-593-210-61

Author Charles B. Jordan

Date 20 April 1962

ABERDEEN PROVING GROUND
MARYLAND

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Coating and Chemical Laboratory
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Maryland

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ABSTRACT

The object of this study was to find an additive capable of solubilizing small amounts of water in mineral oil throughout the temperature range of -65°F to + 400°F.

Hydrophilic substances which were soluble in mineral oil were tried When none proved satisfactory, hundreds of available organic chemicals containing different functional groups were tried, in the event that some of these materials would exhibit unpredicted favorable solubilization properties. The trend of solvency in relationship to carbon content within each individual homologous series was studied.

Although there were instances where solubilization occurred, no single additive or mixture was found which would give the desired results over the specified temperature range.

I. INTRODUCTION

Aberdeen Proving Ground, Maryland, was directed by OCO, reference OMS 5010.11.8020.0, dated 21 April 1961, to conduct research on hydraulic brake fluids with emphasis on non-polar fluids.

Previous studies have shown that petroleum base fluids operate satisfactorily in brake systems and are good preservatives for metals. However, in field tests conducted in 1956 (CCL Report No. 18) it was found that water, which entered the brake system by condensation, was free to corrode metal parts due to its incompatibility with the petroleum base fluid. It is conceivable that an additive or mixture of additives could be placed in the fluid so that small amounts of water could be solubilized.

Military requirements dictate the use of brake fluids throughout all climatic extremes. In order to perform this function satisfactorily, the mineral oil/additive mixture should be capable of retaining a minimum of 1 - 2% water throughout temperature ranges of -65°F. to +400°F.

Since large amounts of additive would change the properties of mineral oil, only concentrations of additive less than 10% were studied.

II. DETAILS OF TEST

A. Mineral Oil

A refined white mineral oil of medium viscosity range was used in this test. The oil remained clear and fluid in the range of -65°F, to + 400°F.

B. Additives

Chemically pure additives or compounds of highest purity obtainable were used.

C. Test Procedure

One drop of distilled water was placed in 90 drops of mineral oil. Up to 10% of the additive or mixture of additives was introduced in small portions with shaking. If solubilization occurred the minimum amount of additive required for a clear solution was determined. Clear solutions were exposed to -40°F and -65°F for periods up to 14 days. If solubilization did not occur at room temperature, the mixture was heated to 180°F. to effect solution if possible.

III. RESULTS OF TESTS (See Appendix)

A sodium hydrocarbon sulfonate was the only single additive capable of giving a clear solution at room temperature. A minimum of nine percent or more of sulfonate in mineral oil was required to dissolve 1% water. Even with this quantity of additive, the water separated at -40°F.

A mixture of sodium hydrocarbon sulfonates in mineral oil sometimes gave clear solutions at -40°F. with 1% water. Results were inconsistent at -65°F indicating that true solutions may not have been formed or supercooling had

occurred.

Mineral oil with mixtures of glyceryl mono oleate and some alcohols (3 - 5 carbons) gave clear solutions with 1% water at room temperature, but precipitates formed in all samples at -40°F. The addition of deiceing agents did not improve results.

One mixture was found which would allow the mineral oil plus 1% water to remain clear at -40°F and -65°F for periods of time up to one week. This mixture contained 4 - 6% glyceryl mono oleate, 3% N, N-dimethyl capryl-caproamide, and percentages of isobutyl alcohol above 5%. However, small crystals were formed when the solution was cooled at -65°F for one week, indicating water separation.

All other single additives and mixtures were unsatisfactory at room temperature.

IV. DISCUSSION

Hydrophilic substances which were soluble in mineral oil were first investigated. When none proved satisfactory, organic substances which were very hydrophilic at one end and very hydrophobic at the other end were tried. Later more than 300 compounds containing different functional groups were studied, in the event that some of these materials would exhibit unpredicted solubilization properties.

Mixtures of compatible hydrophilic and hydrophobic compounds were tried. N,N-dimethyl amides were given much attention because their solubility is inversely proportional to rise in temperature, and most difficulty in solubilization seems to be at lower temperatures.

The trend of solvency in this study followed normal lines in that increasing carbon content of homologous compounds reduced their affinity for water.

This study did not reveal any success by this approach. A new approach should be taken in future studies. The approach would consist of selecting an additive which will chemically react with water to give an oil soluble compound.

V. ACKNOWLEDGEMENT

Experimental data was collected and observations were made by Sp. 4 Jimmie G. Tolar.

VI. REFERENCES

A. Authority: OMS 5010.11.8020.0, dated 21 April 1961.

B. CCL Report No. 18, Field Test of Nitrile Type Synthetic Rubber Brake Cups in Trucks at Yuma, Arizona, dated 27 February 1957.

APPENDIX

Tables

TABLE I

SINGLE COMPOUNDS

1 - 10% Added to 1% Water In Mineral Oil

(No single compound was capable of solubilizaing 1% water in mineral oil over the range of -65°F to 400°F.).

I. Alcohols
   A. Mono hydroxy
   B. Poly hydroxy
   C. Mono hydroxy ethers
   D. Aromatic

II. Phenols
   A. Mono hydric
   B. Poly hydric

III. Amines
   A. Mono amines
   B. Poly amines

IV. Esters

V. Ketones

VI. Acids and Acid Anhydrides

VII. Hydrocarbons

VIII. Halogenated Hydrocarbons

IX. Ethers

X. Salts of Organic Acids

XI. Sulfonates

XII. Inorganic Esters

XIII. Amine Salts

XIV. Metal Organics

XV. Benzothiazyls

XVI. Nitriles

XVII. Hydrazines

XVIII. Acid Halides

XIX. Oximes

TABLE I CONTINUED

XX. Isocyanates

XXI. Sulfonates

XXII. Peroxides

XXIII. Amides

I. Alcohols

A. Mono-hydroxy compounds

No. Carbons	Name
1	Methanol
2	Ethanol
2	2-Chloroethanol
3	Propanol-1
3	Propanol-2
3	Propyne-1-ol-3
4	Butanol-1
4	Butanol-2
4	2-Methyl Propanol-1
4	2-Methyl Propanol-2
5	Pentanol-1
5	2-Methyl-Butanol-1
5	2-Methyl-Butanol-2
5	2-Methyl-Butanol-3
5	Cyclopentanol
6	Hexanol-1
6	2-Methyl Pentanol-1
6	4-Methyl Pentanol-2
6	2-Ethyl Butanol-1
6	Cyclohexanol
6	Diacetone Alcohol
7	Heptanol-1
7	Heptanol-3
7	Heptanol-4
7	2,4-Dimethyl Pentanol-3
8	Octanol-1
8	Octanol-2
8	2-Ethyl Hexanol-1
9	N-Nonyl Alcohol
10	N-Decyl Alcohol
11	Undecyl Alcohol
11	Undecylenyl Alcohol
12	Dodecyl Alcohol

B. Polyhydroxy compounds

No. Carbons	Name
2	Ethylene Glycol
3	1,2-Propylene Glycol
3	Glycerol
3	1,3-Propylene Glycol
4	Diethylene Glycol
4	2-Butyne-1,4-Diol
4	1,3-Butanediol
4	2,3-Butanediol
5	1,5-Pentanediol
6	2-Methyl-2,4-Pentanediol
6	Hexylene Glycol
6	Triethylene Glycol
6	Mannitol
8	Octylene Glycol
8	2,5-Dimethyl-3-Hexyne-2,5-Diol
18	Tetra Hydroxyl Castor Oil
18	Ricinoleyl Alcohol
18	12-Hydroxy Stearyl Alcohol
Polymer	Polymerized Trimethyl Dihydoxy Quinoline

C. Mono Hydroxy ethers

No. Carbons	Name
3	Ethylene Glycol Mono-Methyl Ether
4	Ethylene Glycol Mono Ethyl Ether
4	Propylene Glycol Mono Methyl Ether
4	2,2'-Dimethoxy Ethanol
4	Methoxy Propanol
5	4-Methoxy Butanol-1
5	Propylene Glycol Mono Ethyl Ether
5	Diethylene Glycol Mono Methyl Ether
5	3-Methoxy Butanol-1
6	Ethylene Glycol Mono-n-Butyl Ether
6	Diethylene Glycol Mono-Ethyl Ether
7	2-Methoxy-2-Methyl-Pentanol-4
8	Ethylene Glycol Mono-n-Hexyl Ether
8	Diethylene Glycol Mono-n-Butyl Ether
16	Diethylene Glycol Monolaurate

D. Aromatic Alcohols

Benzyl Alcohol
N-Phenoxy Ethanol
P-Tert-Amyl-Phenoxy Ethanol
O-Sec-Amyl Phenoxy Ethanol

II. Phenols

A. Mono-Hydric Phenols

TABLE I CONTINUED

A. Mono-Hydric Phenols

No. Carbons	Name
6	Phenol
6	O-Chlorophenol
6	P-Chlorophenol
6	P-Nitro Phenol
6	Picric Acid
7	O-Cresol
7	P-Cresol
7	M-Cresol
7	Hydroquinone Mono Methyl Ether
9	8-Hydroxy Quinoline
9	Alkyl Phenol
10	Carvacrol
12	P-Hydroxy Diphenyl
12	O-Hydroxy Diphenyl
14	Alizarin
15	2,6-Di-t-butyl-p-cresol
15	Octyl Cresol
15	Bisphenol A
19	Phenol Red

B. Polyhydric Phenols

No. Carbons	Name
6	Hydroquinone
6	Pyrogallol
6	Resorcinol
7	Toluhydroquinone
10	P-tert-butyl Catechol
10	1,5-dihydroxy Naphthalene
10	1,6-dihydroxy Naphthalene
12	Phenyl Hydroquinone
12	4,4-dihydroxy Diphenyl
14	Octyl Resorcinol
14	2,5-di-t-butyl Hydroquinone
20	Phenolphthalein
23	Cresophthalein

III. Amines

A. Mono-amines

	No. Carbons	Name
1. Primary	4	Tris (hydroxyl methyl) Amino Methane
	7	Amino Benxoic Acid
2. Secondary	4	Diethyl Amine
	4	2-Pyrolidone
	5	Pyridine
	6	Cyclohexyl Amine
	8	Di-n-butyl Amine

TABLE I CONTINUED

	No. Carbons	Name
	10	N-butyl-p-amino-phenol
	12	Dicyclohexyl Amine
	16	Di-2-ethyl Hexyl Amine
3. Tertiary	5	N-methyl Morpholine
	6	Triethyl Amine
	9	N-vinyl-2-pyrolidone
	10	N-phenyl Morpholine
	10	Potassium Ethylene Diamine Tetracetate
	10	Sodium Ferric Ethylene Diamine Tetracetate
	12	N,N-di-n-propyl Aniline
	15	Tri-N-amyl Amine

B. Poly Amines

	No. Carbons	Name
1. Primary - Secondary	4	Aminoethyl Ethanol Amine
2. Secondary	14	Disalicylal Propylene Diimine
	14	Disalicylidene Propylene Diamine
3. Tertiary	7	3-N,N-(dimethylamine) Propyne-1
	8	1,4-Bis(dimethylamine) Butyne-2
	14	N,N-di-sec-butyl-p-phenylene Diamine

IV. Esters

No. Carbons	Name
4	2-Chloroethyl Acetate
4	Butyrolactone
5	Isopropyl Acetate
6	Butyl Acetate
6	Ethylene Glycol Monoethyl Ether Acetate
7	N-amyl Acetate
7	Propylene Carbonate
8	Methyl Salicylate
8	Diethylene Glycol Diacetate
10	Propyl Gallate
10	Isopropyl Benzoate
12	N-Butyl Phthalate
13	Phenyl Salicylate
15	Tri-n-butyrin
20	Diphenyl Phthalate
21	Propylene Ricinoleate
21	Glyceryl Mono Oleate
31 - 42	Lanolin
57	Glyceryl Trioleate
Poly	Polyethylene Glycol 200-mono Ricinoleate

TABLE I CONTINUED

No. Carbons	Name
Poly	Sorbitan Fatty Acid Ester
Poly	Polyoxyethylene Ester of Fatty and Resin Acids
Poly	Polyethylene Glycol 400-di-tri-Ricinoleate

V. Ketones

No. Carbons	Name
3	Acetone
4	Methyl Ethyl Ketone
4	2-pyrrolidone
6	Methyl Isobutyl Ketone
6	Cyclohexanone
6	Diacetone Alcohol
6	P-quinone
7	Methyl N-amyl Ketone
9	Methyl N-hexyl Ketone
9	Diisobutyl Ketone
9	N-vinyl-2-pyrrolidone
14	Alizarin
15	Alizarin Cyanine Green

VI. Acids & Acid Ahydrides

No. Carbons	Name
1	Formic
2	Acetic, Glacial
2	Oxalic
3	Propionic
3	Propiolic
3	Lactic
4	N-butyric
4	Iso-butyric
4	Acetic Anhydride
6	N-caproic
6	Iso-caproic
7	Heptanoic
7	P-toluene Sulfonic
7	Benzoic
7	Aminobenzoic
7	P-hydroxy Benzoic
7	Salicylic
7	Pyrogallic
8	N-caprylic
8	Octanoic
9	Timethyl-n-caproic
9	Cinnamic
11	Undecanoic
12	Lauric
14	Tannic
15	Methyl Red

No. Carbons	Name
18	Stearic
18	Ricinoleic
18	Oleic
Unknown	Sulfonated Castor Oil
Unknown	Sulfonic Acid of Mineral Oil

VII. Hydrocarbons

A. Aliphatic

No. Carbons	Name
5-6	Petroleum Ether
5-8	Mineral Spirits
6	N-hexane
6	Cyclohexane
6	Cyclohexene
6	2-methyl Pentane
6-7	Naphtha
7	N-heptane
8	N-octane
8	2,2,4-trimethyl Pentane
8	Octene (1 & 2)

B. Aromatic

No. Carbons	Name
6	Benzene
7	Toluene
8	Xylene

VIII. Halogenated Hydrocarbons

No. Carbons	Name
1	Chloroform
1	Iodoform
1	Carbon Tetrachloride
2	2-Chloroethanol
2	Dibromoethane
2	Tetrachloroethylene
6	Dichlorobenzene
6	Chlorobenzene
6	Bromobenzene
19	Triphenyl Chloromethane

IX. Ethers

No. Carbons	Name
3	Trioxymethylene
4	Diethyl Ether
4	P-dioxane
4	Propylene Glycol Formal
6	Diisopropyl Ether

TABLE I CONTINUED

No. Carbons	Name
8	Triethylene Glycol Dimethyl Ether
10	Tetraethylene Glycol Dimethyl Ether
18	Epoxidized Castor Oil
20	Epoxidized Acetylated Castor Oil
20	Ethoxylated Castor Oil

X. Salts of Organic Acids

No. Carbons	Name
1	Sodium Carbonate
2	Lead Acetate
2	Guanidine Carbonate
2	Sodium Methyl Carbonate
6	Sodium Citrate
7	Sodium Benzoate
7	Sodium Mercaptobenzothiozole
8	Potassium Acid Phthalate
9	Cinnamic Acid Sodium Salt
10	Copper-8-quinolinolate
10	Sodium Ferric Ethylene Diamine Tetra Acetate
10	Potassium Ethylene Diamine Tetra Acetate
11	Calcium Undecanoate
18	Copper Stearate
18	Zinc Dibutyl Dithiocarbamate
22	Zinc Diamyl Dithio Carbamate

XI. Sulfonate

No. Carbons	Name
8	Sodium Xylene Sulfonate
10	Napthalene Sulfonic Acid Sodium Salt
26	* Sodium Hydrocarbon Sulfonate, Mol. Wt 430
28	Barium Dinonyl Naphthalene Sulfonate, Mol Wt. 1055
30+	Sodium Hydrocarbon Sulfonate, Mol. Wt. 500+
Unknown	Calcium Sulfonate

* Capable of clear soln at room temperature if 9% or more sulfonate is added to 1% water in mineral oil. At -40°F solutions are cloudy with crystalline separation.

XII Inorganic Esters

No. Carbons	Name
17	2,6-di-t-butyl-4-methyl-di-n-butyl Borate
18	Trihexylene Glycol Borate

TABLE I CONTINUED

No. Carbons	Name
18	Trihexylene Glycol Biborate
22	2,6-di-t-butyl Phenyl-di-n-butyl Borate
24	Tri-2-ethyl Hexyl Phosphate
Unknown	Alkyl Phosphate 50% in Ethylene Glycol

XIII. Amine Salts

No. Carbons	Name
6	Di-isopropanol Amine Phosphate
6	Triethanol Amine Phosphate
9	Tri-isopropanol Amine Borate

XIV. Metal Organics

No. Carbons	Name
8	Ethyl Tri-ethoxy Silane
12	Di-butyl Tin Maleate
32	Dibutyl Tin Dilaurate

XV. Benzothiazyls

Benzothiazyl Disulfide
Mercaptobenzothiazole
Phenyl Biguanide Mercaptobenzothiazole Salt

XVI. Nitriles

No. Carbons	Name
3	B-hydroxy Propionitrile
7	Benzonitrile

XVII. Hydrazines

2,4-dinitrophenyl Hydrazine

XVIII. Acid Halides

3,5-dinitro benzoyl Chloride

XIX. Oximes

Salicylaldoxime

XX. Isocyanates

P-nitro Phenyl Isocyanate

XXI Aromatic Sulfonamides

P-toluene Sulfonamide

TABLE I CONTINUED

XXII. Peroxides

Benzoyl Peroxide

XXIII. Amides

No. Carbons	Name
1	Formamide
4	N,N-dimethyl Acetamide
5	N,N-dimethyl Propionamide
6	N,N-dimethyl Butyramide
16	N,N-dimethyl Capryl-caproamide
14	N,N-dimethyl Lauramide
20	N,N-dimethyl Oleamide

TABLE II

MIXTURES

Added to 1% water in mineral oil.

I. Sulfonates
II. Glyceryl Mono Oleate and Mono Hydroxy Compounds
III. Glyceryl Mono Oleate and Poly Hydroxy Compounds
IV. Glyceryl Mono Oleate and Glycol Ether
V. Glyceryl Mono Oleate, Isobutyl Alcohol and N,N-dimethyl Capryl-caproamide

I. Sulfonates (Mixture of two sodium hydrocarbon sulfonates), added to 1% water in mineral oil.

#1 Mol. Wt. Approx. 500, #2 Mol. Wt. Approx. 430.

Percent Added		
#1	#2	Appearance of Mixture
1 - 10%	0%	Cloudy at room temperature.
8 - 9%	1%	Clear at room temperature, frozen at -40°F.
8%	2%	Clear at room temperature, varying from clear to slightly cloudy at -40°F. Crystalline separation at -65°F.
1 - 7%	3%	Clear at -40°F. except 7% (inconsistant at -65°)
1 - 6%	4%	Clear at room temperature, clear at -40°F but extremely viscous.

TABLE II CONTINUED

#1	#2	Appearance of Mixture
0%	9 & 10%	Clear at room temperature, crystalline separation at -40°F.
1%	5% and above	Clear at room temperature, crystalline separation at -40°F.

II. A. 1 - 10% Glyceryl Mono Oleate, 1 - 10% Mono Hydroxy Compounds, Added to 1% Water in Mineral Oil.

Alcohols Added

No. Carbons	Name	Appearance of Mixture
1	Methyl	Cloudy in all proportions at room temp.
2	Ethyl	Cloudy in all proportions at room temp.
3	N-propyl	Cloudy with less than 6% ester at room temp.
3	Iso-propyl	Cloudy with less than 6% ester at room temp.
4	N-butyl	Clear with 4% ester & 4% alc at room temp., crystalline separation at -40°F.
4	Isobutyl	Clear with 4% ester & 4% alc at room temp., crystalline separation at -40°F.
4	Sec Butyl	Clear with 5% ester & 3% alc at room temp., crystalline separation at -40°F.
4	T-butyl	Clear with 6% ester & 3% alc., crystalline separation at -40°F.
5	N-amyl	Cloudy in all proportions.
5	3-methyl butyl	Clear with 4% ester & 6% alc. at room temperature, crystalline separation at -40°F.
6	N-hexyl	Cloudy in all proportions at room temp.
6	4-methyl Pentanol-2	Cloudy in all proportions at room temp.
8	2-ethyl Hexyl	Cloudy in all proportions at room temp.

B. 4 - 6% Glyceryl Mono Oleate, 2 - 4% Isobutyl Alcohol, and Deicing Agents, Added, as Indicated, to 1% Water in Mineral Oil.

Deicing Agent - Percent Added	Appearance of Mixture
½ - 4% Pyrrolidone	Cloudy at room temperature.
½ - 4% N-methyl Pyrrolidone	Cloudy at room temperature.
½ - 4% N-vinyl-2-pyrrolidone	Cloudy at room temperature.
½ - 4% 1,2,6-hexanetriol	Clear at room temperature, cloudly at -40°F.

III. Glyceryl Mono-Oleate and Poly Hydroxy Compounds

A. 4% Glyceryl Mono Oleate, 1 - 10% Polyol, Added to 1% Water in Mineral Oil.

TABLE II CONTINUED

Polyhydroxy Compound Added

No. Carbons	Name	Appearance of Mixture
2	Ethylene Glycol	Cloudy in all proportions at room temp.
3	Propylene Glycol	Cloudy in all proportions at room temp.
3	Glycerol	Cloudy in all proportions at room temp.
4	2,3-butane Diol	Cloudy in all proportions at room temp.
4	1,3-butane Diol	Cloudy in all proportions at room temp.
4	Diethylene Glycol	Cloudy in all proportions at room temp.
4	2-butyne-1,4-diol	Cloudy in all proportions at room temp.
6	2,4-dihydroxy-2-methyl Pentane	Cloudy in all proportions at room temp.
6	1,2,6-hexane-triol	Cloudy in all proportions at room temp.
6	Dipropylene Glycol	Cloudy in all proportions at room temp.
8	2,5 Dimethyl-3-hexyne-2,5-diol	Cloudy in all proportions at room temp.
8	Octylene Glycol	Cloudy in all proportions at room temp.

B. 8% Glyceryl Mono Oleate, 1 - 2% Same Polyhydroxy Compounds, Added to 1% Water in Mineral Oil.

Results: All mixtures were cloudy in all proportions at room temperature.

IV. 4% Glyceryl Mono Oleate and 1 - 6% Glycol Ethers, Added to 1% Water in Mineral Oil

Glycol Ethers Added

No. Carbons	Name	Appearance of Mixture
3	Ethylene Glycol Mono Methyl Ether	Cloudy in all proportions at room temp.
4	Ethylene Glycol Mono Ethyl Ether	Cloudy in all proportions at room temp.
4	Propylene Glycol Mono Methyl Ether	Cloudy in all proportions at room temp.
4	2,2'-dimethoxy Ethanol	Cloudy in all proportions at room temp.
5	Propylene Glycol Mono Ethyl Ether	Cloudy in all proportions at room temp.
5	4-Methoxy Butanol-1	Cloudy in all proportions at room temp.
6	Ethylene Glycol Mono-n-butyl Ether	Cloudy in all proportions at room temp.
6	Diethylene Glycol Mono-n-ethyl Ether	Cloudy in all proportions at room temp.
8	Ethylene Glycol Mono-n-hexyl Ether	Cloudy in all proportions at room temp.
8	Diethylene Glycol Mono-n-butyl Ether	Cloudy in all proportions at room temp.
16	Diethylene Glycol Mono Laurate	Cloudy in all proportions at room temp.

TABLE II CONTINUED

V. Glyceryl Mono Oleate, Isobutyl Alcohol and N,N-dimethyl Capryl-caproamide.

A. Percent-Added to 1% Water in Mineral Oil.*

Ester	Amide	Alcohol	Appearance of Mixture
4%	3%	1 - 2%	Cloudy at room temperature.
		3 - 5%	Clear at room temperature.
5%	3%	1 - 2%	Cloudy at room temperature
6%	3%	1%	Cloudy at room temperature

*Mixtures containing less than 4% ester were always cloudy regardless of amount of alcohol added. Alcohol above 5% gave clear solutions at room temperature and -40°F. All solutions had crystalline separation at -65°F.

B. 4% Ester, 5% Alcohol, Above 2% Amide, Added to 1% Water in Mineral Oil.

Results: 2 - 12% amide, mixtures cloudy at -40°F. 14% amide and above - clear and fluid at -40°F.

C. 4% Ester, 6% Alcohol, 1 - 24% Amide, Added to 1% Water in Mineral Oil

Results: Room temperature all mixtures clear.
-40°F: 1 - 18% amide crystalline separation, 19% and above slightly cloudy.
-65°F.: All mixtures, crystalline separation.

D. 4.3% Ester, 4.3% Alcohol, 1 - 20% Amide, Added to 1% Water in Mineral Oil.

Results: Room temperature: All mixtures clear.
-40°F: All mixtures cloudy

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Commander Officer Raritan Arsenal ATTN: NICP(46) Metuchen, New Jersey	1
Department of the Army - Other Army Agencies	
Ordnance Office, Headquarters U.S. Army Caribbean, Corozal Fort Clayton, Canal Zone	1
Other Goverment Agencies	
Office of Technical Services Acquisitions Section Department of Commerce Washington 25, D C.	200
Foreign Address	
Ministry of Supply Staff British Joint Services Mission 1800 K Street, N. W. Washington 6, D. C.	2
Canadian Army Staff ATTN: GSO-1 A&R Section 2450 Massachusetts Avenue, N. W. Washington 8, D. C.	2

AD No_____Accession No_____ Unclassified

Coating & Chemical Laboratory, Aberdeen Proving Ground, Md., CCL # 118 - ENGINEERING STUDIES ON SOLUBILIZATION ADDITIVES FOR WATER IN MINERAL OIL - Charles B. Jordan, Rpt No. 118, 20 April 1962, pgs, OMS 5010.11.8020.0 DA Proj No. BR 593-210-61

The object of this study was to find an additive capable of solubilizing small amounts of water in mineral oil throughout the temperature range of -65°F to + 400°F.

Hydrophilic substances which were soluble in mineral oil were tried. When none proved satisfactory, hundreds of

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